

ABLATION OF PICA-LIKE MATERIALS: SURFACE OR VOLUME PHENOMENON?

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The ablation of the char layer in ablative material is usually described in term of recession velocity of the overall surface. This description is valid for dense materials. However, the recession of the average surface in porous materials may not recede uniformly (as in figure 1), but the individual fibers may progressively vanish, see figure 2. In the second regime, ablation is no longer a surface phenomenon, but is volumetric. Seen from a surface point of view, three important consequences follow this volume ablation regime: (1) the effective reactivity of the material is significantly increased, (2) the material weakens in volume and is subject to strong mechanical erosion (spallation), and (3) the ablation enthalpy distributed in volume modifies the thermal response of the material. In this regime, surface ablation models should be replaced by volume ablation models for a more accurate description of the outer layer of the material. In the presentation, a first attempt to couple volume ablation with pyrolysis is done using a multiscale approach.

In an effort to derive phenomenological models for the volume ablation regime, three-dimensional (3D) simulations of isothermal ablation in air of a low-density material made of carbon fibers distributed randomly are performed (see figures 1 and 2). A parametric study shows that ablation is either a surface or a volume phenomenon depending on the value of Thiele number (reaction/diffusion competition inside the porous media), when advection due to pyrolysis and thermal gradients are neglected. A macroscopic model for volume ablation is derived analytically using homogenization (averaging). The model is a set of partial differential equations, similar to traditional pyrolysis models. Simulations of coupled pyrolysis and volume ablation are presented. The possible spallation of PICA due to volume ablation during Stardust re-entry is discussed under the light of this model.



Fig 1 Porous medium made of random carbon fibers : Surface ablation

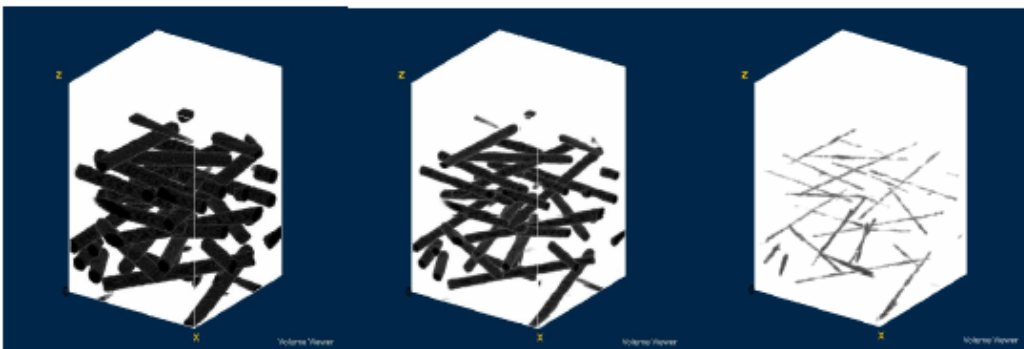


Fig 2 Porous medium made of random carbon fibers : Volume ablation